

Effect of Pelvic Muscle Exercise on Transient Incontinence During Pregnancy and After Birth

CAROLYN M. SAMPSELLE, PhD, RNC, JANIS M. MILLER, PhD, RN,
BARBARA L. MIMS, PhD, RN, JOHN O. L. DELANCEY, MD,
JAMES A. ASHTON-MILLER, PhD, AND CATHY L. ANTONAKOS, PhD

Objective: To test the effect of pelvic muscle exercise on postpartum symptoms of stress urinary incontinence and pelvic muscle strength in primigravidas during pregnancy and postpartum.

Methods: A prospective trial randomized women into treatment (standardized instruction in pelvic muscle exercise) or control (routine care with no systematic pelvic muscle exercise instruction). Urinary incontinence symptoms were measured by questionnaire. Pelvic muscle strength was quantified by an instrumented gynecologic speculum. Time points were 20 and 35 weeks' gestation and 6 weeks, 6 months, and 12 months postpartum.

Results: Outcomes are reported for 46 women with vaginal or cesarean birth and for a subsample of 37 women with vaginal birth. Longitudinal analyses are reported for cases with complete data across time points. Diminished urinary incontinence symptoms were seen in the treatment group, with significant treatment effects demonstrated at 35 weeks' gestation ($F [1,43] = 4.36, P = .043$), 6 weeks postpartum ($F [1,43] = 4.94, P = .032$), and 6 months postpartum ($F [1,43] = 4.29, P = .044$). A repeated measures analysis of variance showed a significant interaction between time and treatment for urinary incontinence ($F [4, 41] = 2.83, P = .037$). A significant effect of initial pelvic muscle strength was demonstrated; ie, pelvic muscle strength at 20 weeks' gestation predicted significantly 12-months postpartum strength ($F [1, 13] = 8.12, P = .014$). Group differences in pelvic muscle strength were observed (the treatment group had greater strength at 6 weeks and at 6 months postpartum than did controls), but these differences were not statistically significant.

Conclusion: Practice of pelvic muscle exercise by primiparas results in fewer urinary incontinence symptoms during late pregnancy and postpartum. (*Obstet Gynecol* 1998;91:

406-12. © 1998 by The American College of Obstetricians and Gynecologists.)

Vaginal birth is recognized as an important factor in the development of urinary incontinence in women. Urinary incontinence increases with parity,^{1,2} and in primiparas who deliver vaginally, it has been associated with decreases in pelvic muscle strength of 22%³ to 35%⁴ between pregnancy and the postpartum period. However, absence of vaginal birth does not ensure that women will not develop urinary incontinence. A prevalence of permanent incontinence of 8.8% was reported by women who had a cesarean birth, suggesting that pregnancy without vaginal birth also may be a risk factor.⁵

Pelvic muscle exercise has been shown to increase muscle strength and decrease urine loss in nonpregnant incontinent women.^{6,7} However, data on the impact of pelvic muscle exercise on decreasing urinary incontinence in the childbearing years are sparse. Some investigators demonstrated increased postpartum muscle strength with pelvic muscle exercise, but they did not examine incontinence symptoms concurrently.^{8,9} Others reported no differences in postpartum urinary incontinence with the practice of pelvic muscle exercise but did not measure muscle strength.¹⁰

The single study that examined the two variables concurrently found significantly less incontinence with pelvic muscle exercise; however, follow-up was only for 16 weeks postpartum, and evaluators were not blinded to group assignment.¹¹

The purpose of this prospective randomized trial was to test the effect of pelvic muscle exercise on incontinence symptoms and pelvic muscle strength in primiparas through 12 months postpartum. We tested the following null hypotheses: 1) There will be no difference in antepartum or postpartum urinary incontinence

From the School of Nursing, Division of Health Promotion/Risk Reduction, University of Michigan, Ann Arbor, Michigan; the Institute of Gerontology, University of Michigan; the School of Nursing, Kent State University, Kent, Ohio; Medical School, University of Michigan; and the School of Engineering, University of Michigan.

Supported by National Institutes of Health grants R29-NRO1950 and RO1-NRO-4007.

symptoms between women who receive a standardized pelvic muscle exercise protocol and those who receive routine care, and 2) there will be no difference in antepartum or postpartum pelvic muscle strength between women who receive a standardized pelvic muscle exercise protocol and those who receive routine care.

Materials and Methods

Primigravidas were enrolled at 20 weeks' gestation and followed to 12 months postpartum according to Institutional Review Board–approved procedures. Data were gathered at 20 and 35 weeks' gestation and at 6 weeks, 6 months, and 12 months postpartum. During the study, participants received approximately \$150 in appreciation of their time and commitment. Although study participants were aware of financial compensation before signing the informed consent, the aim of the project was identified broadly as better understanding of the physical changes of childbearing. As there was not a specific focus on urinary incontinence, the possibility of selection bias was felt to be minimal. Inclusion criteria were the following: 18 years of age or older, negative history of genitourinary pathology, plans to remain in the region for at least one year after the birth of the infant, and ability to read and understand English.

Seventy-two women were enrolled initially. Their mean age was 27.2 (standard deviation [SD] 5.5) years, and their mean educational level was 14.9 (SD 2.0) years. Across the 17 months of the study, a number of physical and social constraints resulted in attrition or incomplete data on at least one time point. Eight women elected to discontinue participation citing lack of time; six relocated before the end of the study; five conceived their second child before the 12-month time point; and seven provided incomplete continence information on at least one time point. Eighteen percent (13 of 72) of the women had cesarean births. Because the individuals at any given time point varied, all longitudinal analyses for changes in continence status were conducted using a constant sample of 46 women that included both vaginal and cesarean births and a subsample of 37 vaginal births, all of whom had complete data across the 17 months of the project. The number of women ($n = 16$) who had complete data across the five time points of the study for the speculum measures was much smaller than for the survey questions on incontinence. This was due, especially at 35 weeks' gestation, to contraindications for vaginal examination such as pelvic rest or vaginitis, to travel constraints, and to equipment malfunction. In this case, with a small subsample, where it is unlikely to find a significant result, it was still of interest to examine the direction of the

influence of the treatment. No significant differences in age, race, or educational status were found between the group of women who were lost to follow-up and the group with complete data through 12 months postpartum.

At 20 weeks' gestation, after collection of baseline data, women were randomized into a treatment group, which received standardized instruction in pelvic muscle exercise, or a control group, which received routine care with no systematic pelvic muscle exercise program. Randomization was accomplished using a computer-generated random numbers table. Group assignment was conducted by a clerical member of the project staff.

All muscle strength and urinary incontinence symptom data were collected by an investigator who was blinded to participant group status. The single-blinding was accomplished through use of a second individual, not involved in assessment of urinary incontinence symptoms or muscle strength, who conducted the intervention.

The pelvic muscle exercise protocol used has been described in detail elsewhere.¹² Briefly, the pelvic muscle exercise prescription was tailored to the woman's individual ability, with muscle identification exercises preceding strength-building efforts. Correct pelvic muscle contraction technique was verified in each participant, with additional education provided as indicated. The number of contractions recommended for strength building was 30 per day at maximum or near-maximum intensity.

A measure of pelvic muscle strength was obtained by quantifying the force of a maximum voluntary contraction using an instrumented speculum. A measure of self-reported symptoms of urinary incontinence was obtained by questionnaire.

The instrumented speculum was a new device developed for the purposes of this study. It was adapted from a standard gynecologic speculum and is positioned in a similar manner. When in position, the upper and lower segments of the speculum were approximately 2 cm apart. Strain gauges attached to the upper and lower surfaces of the speculum quantified the force of a single pelvic muscle contraction in newtons. In vitro calibration of the instrumented speculum using data obtained on three different days demonstrated better than 3% of an average value from one day to the next. In vivo testing showed repeatability of 13% from minute to minute and 27% from week to week. The highest level of force generated during a maximal isometric effort was defined as the maximum voluntary contraction force. Two maximum voluntary contractions were elicited during the protocol. The best of these two efforts was used in the analysis. Pearson's correlations of the two maximum voluntary contractions at

Table 1. Pretreatment Sample Characteristics, Pelvic Muscle Strength, and Urinary Incontinence

	Treatment group			Control group		
	<i>n</i>	mean (\pm SD)	%	<i>n</i>	mean (\pm SD)	%
Age (y)	34	28.2 (\pm 5.6)		38	26.3 (\pm 5.4)	—
Education (y)	34	15.2 (\pm 2.0)		38	14.6 (\pm 2.0)	—
Race						
Euro-American	28		90.3	29		82.9
Black	3		9.7	6		17.1
Maximum voluntary contraction (newtons)	29	11.1 (\pm 6.4)		33	12.4 (\pm 7.3)	
Severity of urinary incontinence symptoms (points)	33	0.33 (\pm 0.5)		37	0.35 (\pm 0.4)	

Sample differs due to participant omission of items or equipment malfunction.

each time point ranged from .89 ($P < .001$) to .98 ($P < .001$).

A questionnaire that asked about urinary incontinence occurring with any of four events (gentle coughing, hard coughing, sneezing, and laughing) was administered at each clinic visit. Severity of incontinence was assessed for each item, and points were assigned depending on whether the activity resulted in no leakage (0), dampness (1), wetness (2), or soaking (3). Average scores were generated across the four events at each time point. Instrument reproducibility with a one-week interval for 11 nonpregnant individuals was .91 ($P < .001$).

The analyses followed the intent-to-treat model.^{13,14} That is, once a woman was randomized to the treatment group, she remained in that group regardless of her reported practice of pelvic muscle exercise. Women who ultimately had a cesarean birth remained in their designated group. The evaluation of urinary incontinence outcomes was conducted for women with vaginal birth and also for the total sample, as women who have given birth by cesarean have reported onset of postpartum urinary incontinence.⁵

The standard Statistical Package for the Social Sciences and BMDP Statistical Software packages (SPSS Inc., Chicago, IL) were used for analysis. Change scores were calculated for the dependent measures of urinary incontinence symptoms and pelvic muscle strength by subtracting the scores at a given time from the baseline 20-week score; thus, each woman served as her own control. The multivariate approach to repeated measures analysis of variance was used to test the hypotheses of interest to determine whether, overall, the treatment and control groups differed in incontinence symptoms and muscle strength over time. Analysis of covariance, with each woman's initial score as the covariate, also was used to address the hypotheses, providing more detailed information about the pattern of differences between the treatment and control groups

over time. The level of statistical significance was set at $<.05$.

Urinary incontinence results are reported for the cases who had complete survey data across the five time points of the study, ie, vaginal and cesarean births ($n = 46$), and for a subsample with vaginal birth ($n = 37$). Participants who ultimately had a cesarean birth were omitted from the comparisons of pelvic muscle strength because pelvic muscle damage would not be expected to occur. The results are reported for those with vaginal birth who had complete speculum data across the study ($n = 16$).

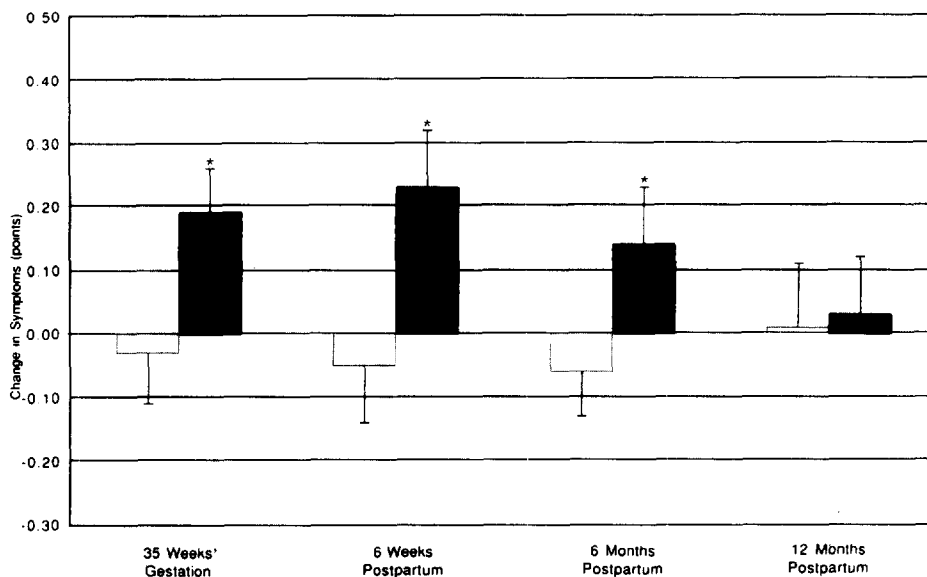
Results

Descriptive group-specific information about the sample is provided in Table 1. At 20 weeks' gestation, no differences were seen between the treatment and control groups in age, level of education, maximum voluntary contraction force, or symptoms of urinary incontinence.

Mean (SD) urinary incontinence symptom scores ranged from 0.3 (0.5) to 0.7 (0.6) points across the time points of the study. No significant differences were noted between treatment and control groups at any of the time points. Mean (SD) maximum voluntary contraction force ranged from 6.6 (3.0) to 13.0 (7.6) newtons. As was the case with comparison of urinary incontinence symptoms, no significant differences were found between groups. These overall comparisons did not control for baseline urinary incontinence symptom score or for baseline maximum voluntary contraction force.

Figure 1 displays the mean differences in urinary incontinence symptom change reported by the treatment and control groups, including vaginal and cesarean births. A repeated measures analysis of variance showed a significant interaction between time and treatment for urinary incontinence ($F [4, 41] = 2.83, P =$

Figure 1. Comparison of change in mean (standard error) urinary incontinence symptoms in women with vaginal and cesarean birth between treatment group ($n = 22$, light shading) and control group ($n = 24$, dark shading) at the four follow-up points. Asterisks designate statistically significant differences at $<.05$.

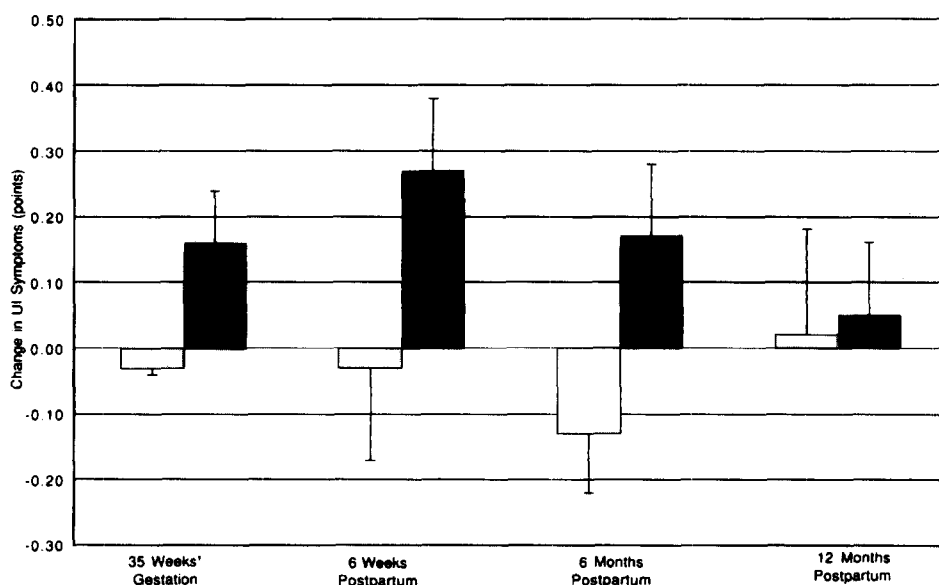


.037). That is, although there was no main effect of treatment or time as independent variables, the interaction between time and treatment indicates that the change in symptoms over time differed for the two groups. Controlling for the baseline urinary incontinence score, analysis of covariance showed significantly less urinary incontinence in the treatment group at 35 weeks' gestation ($F [1,43] = 4.36, P = .043$), 6 weeks postpartum ($F [1,43] = 4.94, P = .032$), and 6 months postpartum ($F [1,43] = 4.29, P = .044$) for cases of women with vaginal and cesarean birth. Women in the control group showed greater urinary incontinence in late pregnancy and up to 6 months postpartum than

women in the treatment group. At the end of the 12-month period, however, this difference disappeared. On the basis of these findings, we rejected hypothesis 1 for the total sample of vaginal plus cesarean births. That is, women in the pelvic muscle exercise group had fewer urinary incontinence symptoms than their control counterparts through 6 months postpartum.

Figure 2 compares the treatment and control group mean changes in reported urinary incontinence symptoms for the subsample of vaginal births. A repeated measures analysis of variance for the subsample of women with vaginal birth found no statistically significant interaction between time and treatment. Analysis

Figure 2. Comparison of change in mean (standard error) urinary incontinence symptoms in women with vaginal birth between treatment group ($n = 16$, light shading) and control group ($n = 21$, dark shading) at the four follow-up points. None of the comparisons was statistically significant. UI = urinary incontinence.



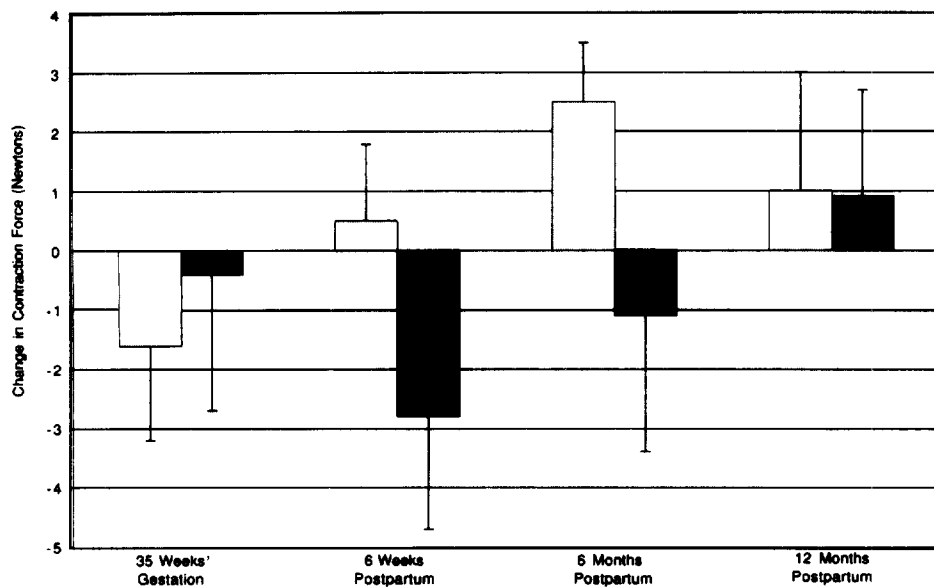


Figure 3. Comparison of change in mean (standard error) maximum voluntary contraction force of pelvic muscle in women with vaginal birth between treatment group ($n = 6$, light shading) and control group ($n = 10$, dark shading) at the four follow-up points. None of the comparisons was statistically significant.

of covariance controlling for baseline urinary incontinence among women with vaginal birth showed treatment effects that approached significance at 6 weeks postpartum ($F [1,34] = 2.89, P = .098$) and at 6 months postpartum ($F [1,34] = 3.41, P = .073$). Thus, for women with vaginal birth, the pattern of symptom differences was similar to that of the total sample, but it was not statistically significant. On the basis of these results, we failed to reject hypothesis 1 for this subgroup.

Results of the repeated measures analysis of variance across the five time points suggested benefit to pelvic muscle strength for the pelvic muscle exercise group; however, the effect of treatment status did not reach statistical significance. Although analysis of covariance did not show a significant effect of treatment on postpartum muscle strength, initial pelvic muscle strength did have a significant effect on strength at 12 months postpartum ($F [1, 13] = 8.12, P = .014$). The pretreatment level of strength accounted for 39% of the variance in outcome strength (coefficient of determination = .386).

To examine strength gains or losses in relation to the baseline 20-week measure, we charted changes in strength across the five data points. That is, a change score was calculated for each case on the basis of strength gain or loss at the respective times compared with the initial measure. Figure 3 compares the treatment and control group mean changes in maximum voluntary contraction force among women with vaginal birth as measured with the instrumented speculum. We noted that the pattern of change observed was in the hypothesized direction, although it was not statistically significant. Therefore, hypothesis 2, testing an effect of

pelvic muscle exercise on pelvic muscle strength, could not be rejected. Given the levels of variability we observed, a sample of 55 participants in each group would have been needed to detect with 80% power the observed effect in pelvic muscle strength change. However, we did note a pattern of greater postpartum strength in the treatment group. It was further observed that the muscle rehabilitation curve was shifted to the left for the pelvic muscle exercise group, suggesting accelerated restitution of muscle function.

Discussion

This study demonstrates that pelvic muscle exercise leads to less self-reported incontinence in late pregnancy and benefits continence status up to 6 months postpartum. We speculate that pelvic muscle exercise may rehabilitate more quickly the pelvic floor after birth injury by building functional reserve prebirth and accelerating the curve of muscle rehabilitation postpartum. The significant interaction effect of treatment with time on urinary incontinence symptoms supports this speculation. Moreover, although women in the control group did not receive standardized protocol instruction, 20% reported practicing pelvic muscle exercise. Thus, our finding of a significant treatment effect on reduction of urinary incontinence symptoms may be a conservative estimate.

Could statistical significance have been reached only because there were more cesarean births in the treatment group than in the control group? The trends depicted in Figures 1 and 2 suggest that the treatment effect was the same in both the sample including

cesarean birth and the sample excluding cesarean birth. Although the findings in the sample excluding cesarean birth were not statistically significant, we believe, given the similar trends in both samples, that sample size is the more likely explanation for the difference in statistical significance.

Despite an observable effect of pelvic muscle exercise on the force of maximum voluntary contraction, the changes did not reach statistical significance in any of the analyses. These findings are consistent with those of Dougherty et al,¹⁵ who reported a nonsignificant benefit of exercise in six-weeks postpartum women. Large standard deviations were present in our data and also were found by Dougherty et al.¹⁵

It is noteworthy that the pattern of muscle strength change fits the timing of incontinence change; thus, muscle strength also seemed to return earlier to the women in the exercise group. To further explore the relationship between muscle strength and incontinence symptoms, we examined correlations across the five time points. Despite the small sample, correlations were consistently negative—the greater the muscle strength, the fewer the incontinence symptoms. However, none of the correlations was significant, and all were weak, ranging from $-.05$ to $-.19$. This suggests that although strength gain may contribute to the treatment effect, it is likely not the sole explanatory variable. An alternative explanation is that practice of pelvic muscle exercise enhances women's awareness of and skill in using the pelvic floor muscles. It has been demonstrated that a properly timed contraction of the pelvic floor muscles can reduce cough-related urine loss before any increase in pelvic muscle strength.¹⁶ Further research is warranted to identify the specific mechanism of pelvic muscle exercise in the diminution of urinary incontinence symptoms.

A decline in pelvic muscle strength from 20 weeks' gestation to 6 weeks postpartum was expected, given the neurologic changes known to occur with vaginal birth.⁴ In fact, at 6 weeks postpartum, women in the treatment group had slightly greater pelvic muscle strength compared with their baseline, whereas their counterparts lost strength, as predicted. Perivaginal muscle restitution was found in both groups by 12 months postpartum. This is consistent with other researchers' findings¹⁷ and probably reflects the normal reparative process. Again, the practice of pelvic muscle exercise appeared to shift the muscle rehabilitation curve to the left, yielding accelerated recovery 6 months earlier, for women in the pelvic muscle exercise group. Tests comparing the treatment and control groups showed no statistically significant differences in infant weight, length of second stage, use of instrumented delivery, or use of anesthetics. Thus, we can eliminate

the possibility that these factors confound the relationship between the treatment and outcomes in this study.

As with any intervention, we did not expect perfect adherence. We categorized as adherent women in the treatment group who reported practice of pelvic muscle exercise at least 75% of the time. At the 35-weeks' gestation time point, 85% of our participants were adherent. During the postpartum year, adherence levels ranged from 62 to 90%. Women in the adherent group reported fewer symptoms of incontinence at all but one of the five time points. Such a trend suggests support for hypothesis 1; however, none of the differences was statistically significant.

The study follow-up through 12 months postpartum expands knowledge of the impact of pelvic muscle exercise on incontinence. It is consistent with the findings reported by Morkved and Bo¹¹ of lower incontinence and greater strength in women doing pelvic muscle exercise at 8 and 16 weeks postpartum and extends the effect period to 26 weeks postpartum. The disappearance of group differences by 12 months postpartum probably is due to normal tissue repair. The potential implications of the protective effect of pelvic muscle exercise for future continence is beyond the scope of this investigation but merits long-term follow-up.

On the basis of these findings, we recommend that providers teach pelvic muscle exercise to antepartum and postpartum women. Given the contribution of baseline pelvic muscle strength to pelvic muscle strength at 12 months postpartum, we recommend that providers evaluate the pelvic muscle strength of nulligravid women who are planning eventual pregnancy and encourage pelvic muscle exercise if any muscle weakness is noted.

References

1. Jolleys JV. Reported prevalence of urinary incontinence in women in a general practice. *BMJ* 1988;48:1300-2.
2. Sommer P, Bauer T, Nielsen KK, Kristensen ES, Hermann GG, Steven K. Voiding patterns and prevalence of incontinence in women. A questionnaire survey. *Br J Urol* 1990;66:12-5.
3. Sampsel C. Pelvic muscle strength changes and stress urinary incontinence associated with childbirth. *J Nurse Midwifery* 1990; 35:371-7.
4. Allen RE, Hosker GL, Smith ARB, Warrell DW. Pelvic floor damage and childbirth: A neurophysiological study. *Br J Obstet Gynaecol* 1990;97:770-9.
5. Iosif CS, Bekasy Z, Rhydstrom H. Prevalence of urinary incontinence in middle-aged women. *Int J Gynaecol Obstet* 1988;26:255-9.
6. Burns PA, Pranikoff K, Nochajski TH, Hadley EC, Levy KJ, Ory MG. A comparison of effectiveness of biofeedback and pelvic muscle exercise treatment of stress incontinence in older community-dwelling women. *J Am Geriatr Soc, MED Supp* 1993;41:M167-74.
7. Dougherty M, Bishop K, Mooney R, Gimotty P, Williams B.

- Graded pelvic muscle exercise. Effect on stress urinary incontinence. *J Reprod Med* 1993;39:684-91.
8. Henderson J. Effects of a prenatal teaching program on postpartum regeneration of the pubococcygeal muscle. *J Obstet Gynecol Neonatal Nurs* 1983;8:403-8.
 9. Morkved S, Bo K. The effect of post-natal exercises to strengthen the pelvic floor muscles. *Acta Obstet Gynecol Scand* 1996;75:382-5.
 10. Sleep J, Grant A. West Berkshire perineal management trial: Three year follow-up. *BMJ* 1987;295:749-51.
 11. Morkved S, Bo K. The effect of post-natal exercises in the treatment of urinary incontinence. *Neurourol Urodyn* 1996;15:412-3.
 12. Miller J, Kasper C, Sampselle C. Review of muscle physiology with application to pelvic muscle exercise. *Urol Nurs* 1994;14:92-7.
 13. Peduzzi P, Detre K, Wittes J, Holford T. Intent-to-treat analysis and the problem of crossovers. *J Thorac Cardiovasc Surg* 1991;101:481-7.
 14. Tsiatis A. Analysis and interpretation of trial results: Intent-to-treat analysis. *J Acquir Immune Defic Syndr* 1990;3(Suppl.2):S120-S3.
 15. Dougherty MC, Bishop KR, Abrams RM, Batich CD, Gimotty PA. The effect of exercise on the circumvaginal muscles in postpartum women. *J Nurse Midwifery* 1989;34:8-14.
 16. Miller J, Ashton-Miller JA, DeLancey JOL. The knack: Use of precisely-timed pelvic muscle contraction can reduce leakage in SUI. *J Am Geriatr Soc* (In press).
 17. Cosner KR, Dougherty MC, Bishop KR. Dynamic characteristics of the circumvaginal muscles during pregnancy and the postpartum. *J Nurse Midwifery* 1991;36:221-5.

Address reprint requests to:
 Carolyn M. Sampselle, PhD, RNC
 School of Nursing, Division II
 University of Michigan
 400 North Ingalls
 Ann Arbor, MI 48109-0482
 E-mail: csampsll@umich.edu

Received August 4, 1997.
Received in revised form November 4, 1997.
Accepted November 6, 1997.

Copyright © 1998 by The American College of Obstetricians and Gynecologists. Published by Elsevier Science Inc.